

A NEW SPECIES OF VIVIPAROUS ASTERINID ASTEROID FROM EYRE PENINSULA, SOUTH AUSTRALIA

by

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ABSTRACT

A new species of asterinid sea star, *Patiriella parvivipara*, is described. It is a viviparous, intra-ovarian brooder similar to *Patiriella vivipara* Dartnall, but it reaches maturity at a much smaller size. The new species occupies an extremely restricted, intertidal habitat under granite rocks and has only been recorded from five localities on the west coast of Eyre Peninsula, South Australia.

INTRODUCTION

The asterinid sea stars are prominent members of the Australian littoral, particularly in south-eastern Australia, where large aggregations of species *Patiriella* are found. This genus was examined by Dartnall (1971) and includes the viviparous species *Patiriella vivipara* Dartnall, 1969, which was the first sea star reported to be an intra-ovarian brooder. A second viviparous species is of obvious interest.

SYSTEMATIC ACCOUNT

ASTEROIDEA

Family ASTERINIDAE Gray, 1840.

Genus *Patiriella* Verrill, 1913.

Patiriella parvivipara new species. Figs. 1-4.

Description of Holotype

A small asterinid sea star with five rays. $R = 3.75$ mm, $r = 3.62$ mm, $R : r = 1.1 : 1$. Body comparatively thin and depressed. At this size it is difficult to give an accurate measurement of body height (vh) because the spinulation causes a relatively greater margin of error than in larger species. The best available value of $vh = 1.48$ mm (averaged from dial caliper and micrometer readings).

Plates of the abactinal surface closely imbricated and few secondary plates present. Abactinal plates very flat and not greatly thickened at their free margins. Four rows of papulae on each side of the radial midline of which only the two inner rows reach the end of the ray. Spines of carinal plates in groups of 4-7; spines of abactinal, interradial area grouped 3-5 to a plate. Abactinal spines range from 0.15-0.11 mm in length and are about 0.1 mm broad at the base. Single madreporite is about 0.4 mm in diameter. Superomarginal plates not distinct from abactinal plates. Proximal inferomarginals each carrying four or five spines, the distal only two.

Distal actinal intermediate plates imbricated and broadly trilobed or convex at their exposed edge, with each plate carrying a single spine, occasionally two, about 0.2 mm long. "Floating", rounded, aspinous, actinal plates present behind mouth plates. The holotype has eight adambulacral plates, the first four bearing two furrow spines of which the distal spine of the pair is the longest (c. 0.4 mm). Distal to adambulacral four the remaining plates carry single furrow spines. Subambulacral spines arranged one to a plate and about the same size as the furrow spines, i.e. larger than the actinal spines.

Most of the oral plates carry five spines, two carry six and two, four. The first spine is the largest (0.9 mm long x 0.25 mm wide at the base), the second is about 0.7 mm long and the remaining three (about 0.4 mm long x 0.1 mm wide at the base) are grouped separately from the first two. The additional spine on two of the oral plates is inserted between the second spine and the final triad and is intermediate in size (c. 0.5 mm long). Suboral spines are absent on all oral plates but one where a short spine is present.

Colour in life

Colour is consistently reddish yellow, Munsell colour 7.5 YR 7/8, varying to 7/6 and 8/6.

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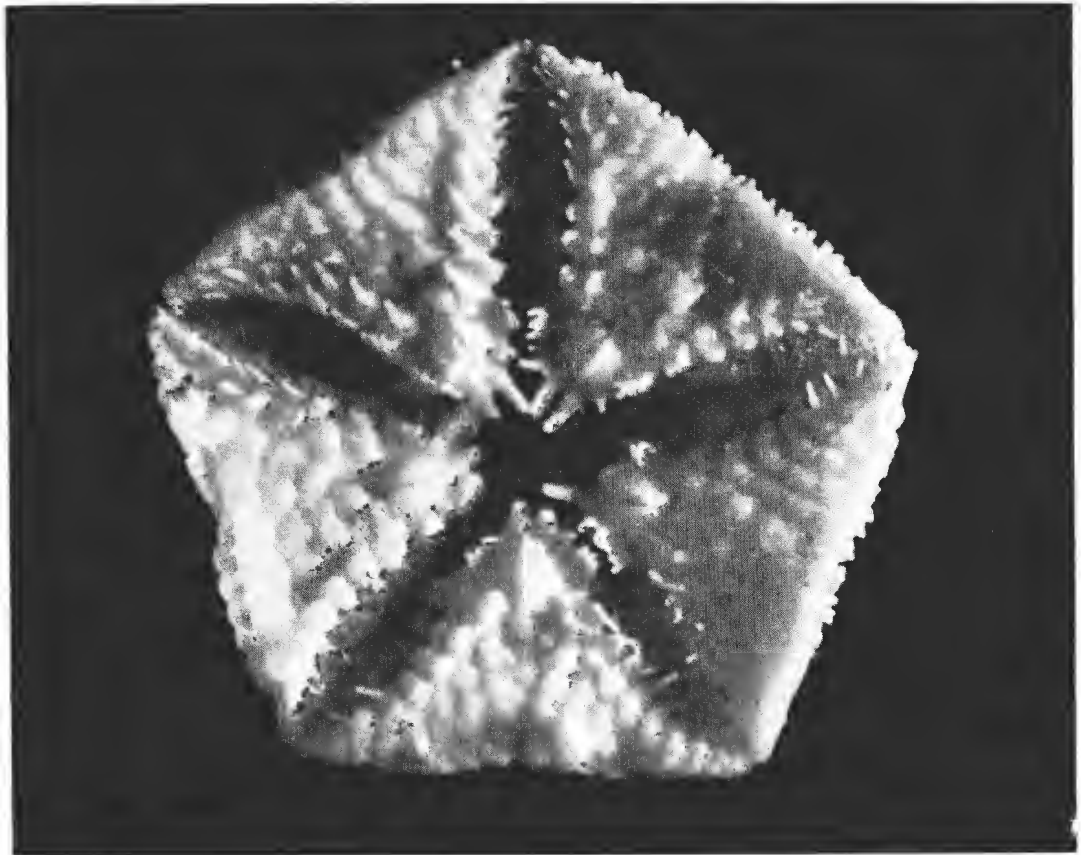


Figure 1. *P. parvivipara*. Holotype SAM K781 (a) Actinal surface

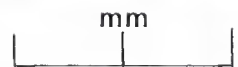


Figure 2. *P. parvivipara*. Holotype SAM K781 (b) Abactinal surface



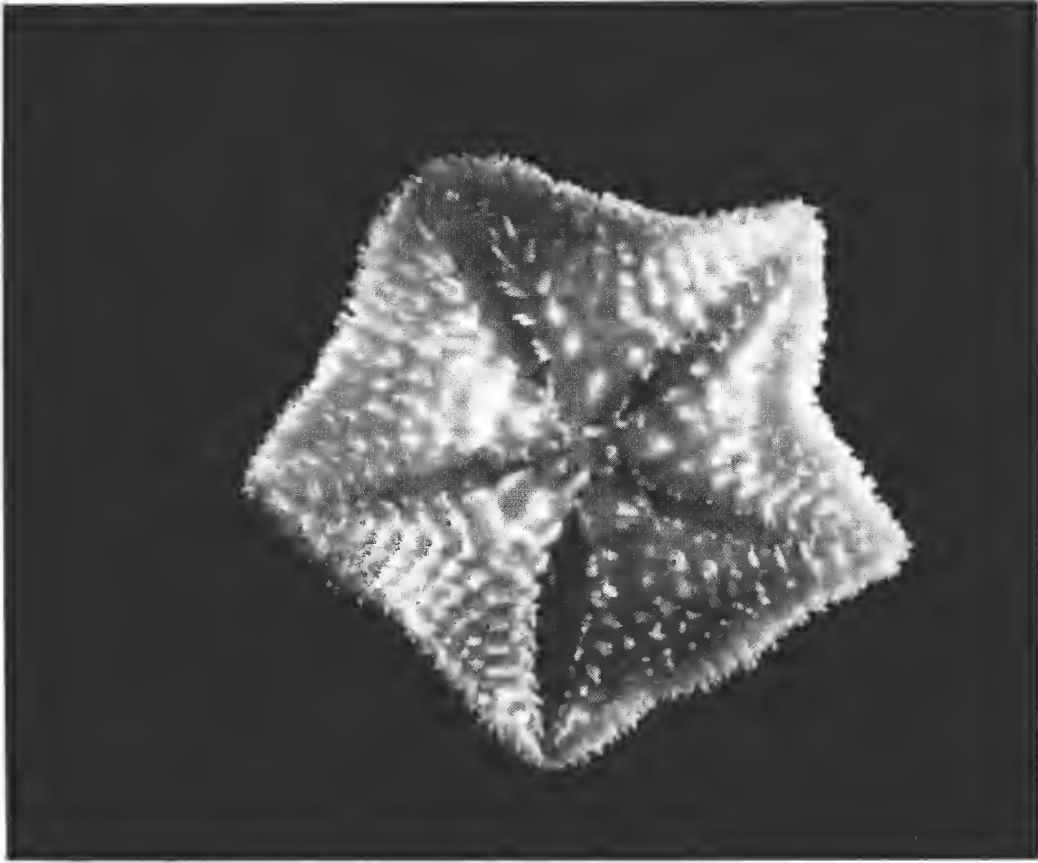


Figure 3. *P. parvivipara*. Paratype SAM K1720 (a) Actinal surface

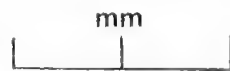
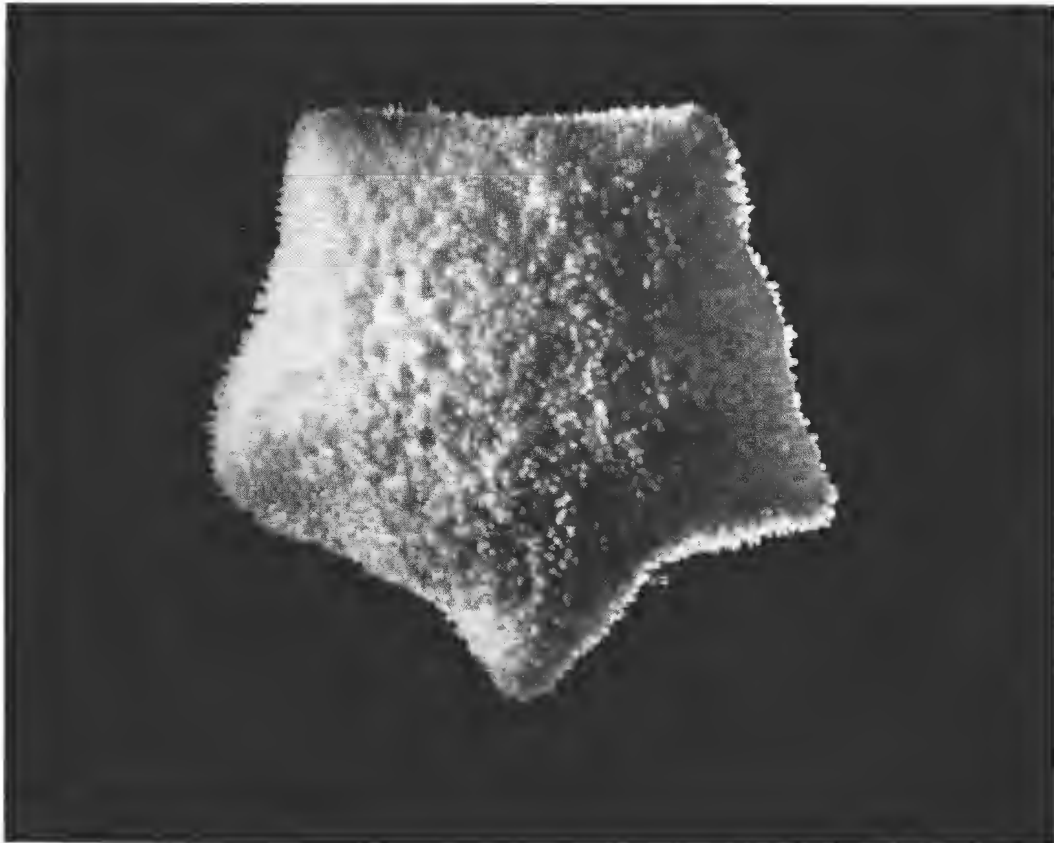


Figure 4. *P. parvivipara*. Paratype SAM K1720 (b) Abactinal surface



Holotype and type locality

One spirit-preserved specimen, SAM K781; Smooth Pool, south of Point Westall, South Australia; Grid Reference: 928203, Department of National Development 1:250 000 series, Map S153-2, Edition 1, Series R502. Collected by W. Zeidler, 28.ii.1975.

Paratypes and other material examined

Abbreviations used: SAM—South Australian Museum; AM—Australian Museum; TM—Tasmanian Museum; NMV—National Museum of Victoria; WAM—Western Australian Museum.

Paratypes

SAM K782 (1 specimen). Smooth Pool, south of Point Westall. Coll. by W. Zeidler, 1.iii.1975.

SAM K1719 (10). Smooth Pool, south of Point Westall. Under rocks intertidally. M. Keough, 19.ix.1975.

SAM K1720 (1). Smooth Pool, near Point Westall. Under granite rocks intertidally. P. Searle, 19.ix.1975. Dried specimen.

WAM 540/77 (1). Smooth Pool, near Point Westall. H. A. Searle, 19.ix.1975.

AM J10916 (1). Smooth Pool, near Point Westall. P. Searle, 19.ix.1975.

TM H1002 (1). Smooth Pool, near Point Westall. H. A. Searle, 19.ix.1975.

NMV H303 (1). Smooth Pool, south of Point Westall. Under rock. Intertidal. H. A. Searle, 19.ix.1975.

Other material

SAM K783 (1). Whittlebee Point, S.A. W. Zeidler, 1.iii.1975.

SAM K784 (1). Whittlebee Point, S.A. W. Zeidler, 1.iii.1975.

SAM K785 (1). Point Brown, S.A. W. Zeidler, 9.viii.1974.

SAM K1713 (c.70). Smooth Pool, near Point Westall. Under granite rocks intertidally. M. Keough, 19.ix.1975.

SAM K1714 (10). Cape Labatt. Under granite rocks intertidally. M. Keough, 15.i.1976.

SAM K1715 (1). D'Anville Bay, southern Eyre Peninsula. J. McNamara, 11.ii.1977.

SAM K1716 (1). Adult with emerging young. Smooth Pool, S.A. H. A. Searle, 19.ix.1975.

SAM K1717 (20). Smooth Pool, near Point Westall. Under granite rocks intertidally. M. Keough, 27.ii.1977.

Note:—Other material is held at all above institutions.

Distribution and habitat

The known distribution of *Patiriella parvivipara* extends from Whittlebee Point near Ceduna, south as far as D'Anville Bay and the species is known from five localities (see Fig. 6). Despite searching, no specimens were found on Yorke Peninsula or on the eastern coasts of Eyre Peninsula. The Western Australian Museum contains no specimens of the species although detailed collecting has only been done along the south-western coast of Western Australia (Mrs. L. M. Marsh, pers. comm.).

Along Eyre Peninsula the species did not occur at a series of other localities searched (see Fig. 6) and at D'Anville Bay considerable searching was necessary to collect the single specimen (J. McNamara, pers. comm.). At Cape Labatt, the population density is moderate, one to five animals per square metre of rock surface examined. At Point Westall, however, densities may reach 2 000 individuals per square metre of rock underside. Even here the animal is extremely localised, only one rock pool of many containing the species. A similar phenomenon was observed at Cape Labatt.

The habitat of the species is also very restricted. *P. parvivipara* occurs in mid- to lower-intertidal rock pools of characteristic appearance. The pools are depressions in an igneous base rock, granite (Smooth Pool, Cape Labatt, Point Brown and Whittlebee Point) or basalt (D'Anville Bay) outcropping along a Pleistocene coastline (Parkin, 1969). Small rocks litter the bottom of the pools and *P. parvivipara* occurs under these rocks (see Fig. 5). At Cape Labatt, some limestone rocks are also present but the species has not been found under these rocks.

The rocks were almost bare of epibiota at Smooth Pool and D'Anville Bay and carried small amounts at Whittlebee Point and Point Brown. At Cape Labatt the rocks were encrusted with calcareous algae, sponges and colonial ascidians as well as mobile species including *Patiriella gunnii* (Gray), *Paranepanthia grandis* (H. L. Clark), *Allostichaster polyplax* (Muller and Troschel), several species of molluscs, the prawn *Leander* sp. and the ophiuroids *Clarkcoma canaliculata* (Lutken), *Ophionereis schayeri* (Muller and Troschel) and



Figure 5. Smooth Pool. Type Locality. Photo courtesy of Bruce Chester.

Ophiactis resiliens Lyman. *P. parvivipara* occurred at the side of rocks partially sheltered by calcareous algae.

The rock pools occurred in sheltered parts of exposed rocky shores and the localities on Eyre Peninsula at which *P. parvivipara* did not occur were of different geology, with the exception of Cape Carnot which was a granite area. Granite areas of Yorke Peninsula were searched unsuccessfully by Mr. W. Zeidler of the South Australian Museum. The habitat is very specialised, a phenomenon shown by many small, cryptic Asterinidae. The eastern limit of distribution is probably fairly precise, although further collecting may extend the range westwards.

Biological observations

Patiriella parvivipara is able to survive high temperatures, as at Smooth Pool the temperature in the pool may exceed 30°C during summer and tidal flushing has little effect on the temperature. Thus the species is able to tolerate temperatures much higher than many asteroids (see Ursin, 1960; Smith, 1940), although it must be noted that the congeneric species *Patiriella exigua* has been recorded from waters of summer temperatures of 30-35°C in South Australia (Shepherd, 1968).

Thermal stress may not be a problem to individuals during summer, but "reproductive stress" may be important. Specimens kept in laboratory aquaria for two months at 15°C

changed very little. When kept at 20-23°C, however, reproduction was induced and over seven days all animals of $R > 2$ mm produced young. Animals which were kept at 12°C and subjected to a rise of similar magnitude (5.5°C) produced no young. These specimens were collected during February, 1977, and examination of specimens collected at the same time showed juveniles to be present. In the first trial, 25 animals were used, and in the second, 10. The results suggest that it is the temperature of 20-23°C, rather than merely a rise in temperature, which stimulates emergence of juveniles.

Juveniles emerged through the abactinal surface of the adult and, in aquaria, their emergence was always fatal to the adults. Most adults contain more than one juvenile and few carried none (see Table 1). Emergent juveniles were as much as 25 per cent of adult diameter. The position of emergence corresponds closely to that of *Patiriella vivipara* (Dartnall, 1969a). Most adults carry many juveniles indicating considerable reproductive potential in the population. At Smooth Pool, the population is sheltered from both wave stress, and competitors and predators while the Cape Labatt and Point Brown populations are more exposed to wave action and to predators and competitors. At Cape Labatt *Patiriella gunnii* and *Paranepanthia grandis* are available as predators upon *Patiriella parvivipara* and prawns are not unknown as sea star predators (Bruce, 1971).

TABLE 1

Distribution of number of young in adult *P. parvivipara* from Smooth Pool at different times of the year. Figures show the frequency of animals carrying given numbers of juveniles.

Month	Number of Young												Adults Examined
	0	1	2	3	4	5	6	7	8	9	10	>10	
February	13	1	1	2	2	1	0	0	0	0	0	0	20
May	3	2	3	1	2	3	3	2	1	0	0	0	20
July	—	—	—	—	1	—	3	—	—	—	—	—	4
September	1	5	4	7	4	4	1	1	1	2	1	1	32

Data from September, 1975 and 1977 were homogeneous, and so were pooled.

The reproduction is extremely efficient, since each adult produces a few young, which are relatively large and thus have a greater probability of survival. It is therefore possible that, because of this and the lack of predators and physical stresses, the Smooth Pool population is approaching maximum density in contrast to the other sites. The role of temperature in reproduction suggests that breeding occurs in December-February as water temperatures rise about 20°C. This behaviour contrasts with that of *P. vivipara*, which breeds throughout the year in colder Tasmanian waters (Dartnall, 1969a), although there may be a December-February breeding peak in that species as Hoggins (1976) believes that breeding is restricted to that period and tank experiments suggest a similar conclusion (G. Prestedje, pers. comm.).

The mode of reproduction does limit widespread dispersal, as evidenced by the distribution of this species (Fig. 6). The method of fertilization is as yet unknown, although Dr. F-S. Chia (pers. comm.) is currently investigating this.

It is possible that cross fertilization occurs, as in *P. vivipara* (F-S. Chia, pers. comm.) and if this is also true for *P. parvivipara* the reproduction would only restrict dispersal, without creating problems of inbreeding.

Some idea of the dynamics of the population of *P. parvivipara* at Smooth Pool may be inferred from measurements of size (i.e. greater radius *R*) and reproductive capacity of samples at different times. In September, 1975, before the summer rise in water temperature, mean *R* of animals was 3.31 ± 0.6 mm, while during February 1976, near the end of the probable reproductive season when warm water temperatures were nearing their end, mean size of the population had fallen, $R = 1.85 \pm 0.6$ mm. In the following May mean size was intermediate, $R = 2.6 \pm 0.631$ mm. (These specimens are no longer held as they were dissected for

juveniles, destroying the specimens). In February, 1977, mean size was again small, $R = 1.95 \pm 0.62$ mm and by July, mostly large animals were present, mean *R* being 2.93 ± 0.52 mm.

The data in Table 1 show that in February, most animals are immature and do not contain juveniles. In May and July many animals, whilst not fully grown, had reached maturity and contained juveniles, and by September, almost all animals were mature and contained juveniles.

The most reasonable explanation for these observations is that the animals are short-lived, juveniles are produced in early summer, grow rapidly and reach maturity between February and June. The animals continue to grow until fully grown the following summer when juveniles emerge. The larger animals present in February are slow-developing animals of the previous year. Since reproduction appears fatal, all adults of a given year die during the summer to be replaced by juveniles, i.e. the data are consistent with almost complete annual turnover of the population. Collection of monthly samples from Smooth Pool is continuing in an attempt to confirm this hypothesis, and more detailed ecological data will be presented at a later date.

Extent of morphological variation

The number of arms is extremely uniform. Of about 300 specimens examined, only one had four arms and one, six. This is less variable than in *P. exigua* where six- and four-rayed specimens are not uncommon (5.5 per cent with other than five rays in 252 Tasmanian specimens (Dartnall, 1969b), but is similar to observed variation in *P. vivipara* where of a sample of 2016 specimens only two had six arms (Dartnall, loc. cit.).

Maximum *R* for the species is 4.7 mm, and sexual maturity is reached at about $R = 2$ mm. This compares with *P. vivipara*, which reaches

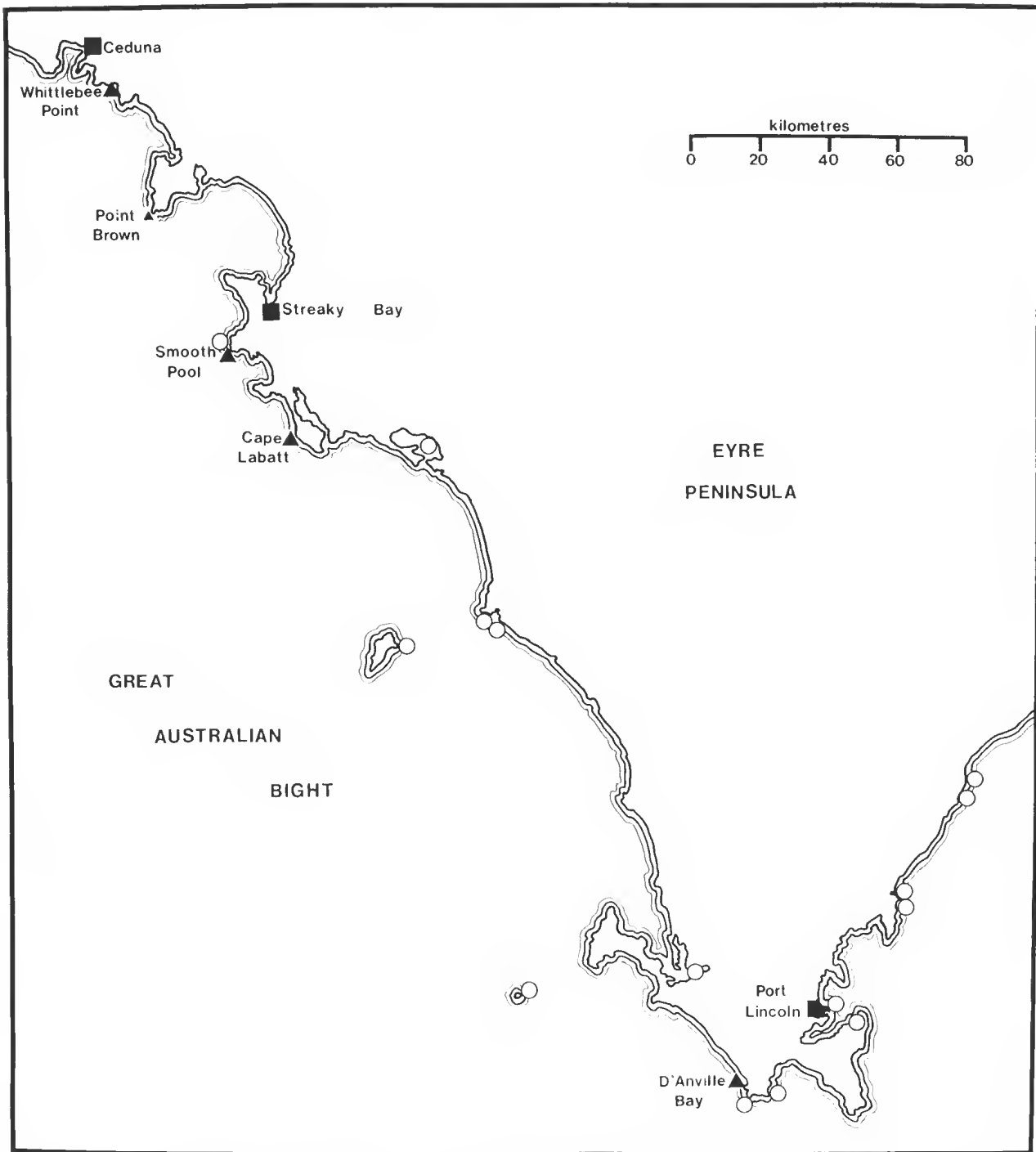


Figure 6. Distribution of *Patiriella parvivipara*. Closed triangles show localities where the species occurs; open circles localities searched unsuccessfully for the species.

TABLE 2
Comparative spine counts of "exigua" group.

	<i>parvivipara</i>	<i>exigua</i> ¹	<i>pseudoexigua</i> ¹¹	<i>vivipara</i> ¹¹¹
Arms	5 (4r; 6r)	5 (4r; 6c)	5 (4r; 6r)	5 (4r; 6r)
R; r range	1.1-1.4	1.08-1.67	1.3	1.1-1.6
Oral spines	4-5 (3r; 6r)	5-6 (4r)	5 not known	6 (5c; 7r)
Suboral spines	0 (1r)	1 (0r)	1 not known	1 (0r)
Actinal * interradial spines/plate	1 (0c; 2c)	1 (0c; 2c)	1 (0c; 2c)	1 (0c; 2c)
Furrow spines*	2 (3r; 1c)	2 (3r; 1r)	3 (2c; 1c)	3 (2c)
Subambulacral spines	1 (2r; 0r)	1 (0r)	1 (2r; 0r)	1 (2c; 0r)
Inferomarginal spines	3 (4, 5, 6c, 7r)	3 (4, 5)	7-9	4-5
Abactinal spines	4-10	4-20	4-20	3-14

Figures show the most common number of spines per plate and parenthesised figures indicate alternative counts. "c" indicates a common occurrence; "r" a rare occurrence.

* The number often varies on a particular animal and one animal may carry 0, 1 and 2 spines on actinal plates and 3, 2 and 1 furrow spines.

¹ Dartnall (1971) and Keough (unpublished observations)

¹¹ Dartnall (1971)

¹¹¹ Dartnall (1969) and Keough (measurements on TM822 and TM927)

maximum size of R > 15 mm, and maturity at 5-6 mm (Dartnall, 1969b; Hoggins, pers. comm.). The larger specimens of *P. parvivipara* (i.e. R > 2 mm) invariably contain juveniles.

Four or five oral spines are usually present in *P. parvivipara* though six occur occasionally. Individuals sometimes had oral plates carrying three, four and five spines on one animal. The usual lack of suboral spines, and smaller size at maturity distinguishes the species from *P. vivipara* in nearly all cases, but a comparison of species within the "exigua" group, *P. exigua*, *P. pseudoexigua*, *P. vivipara* and *P. parvivipara* shows that there is considerable morphological overlap between the species (see Table 2) and that no morphological character or combination of characters suffices to distinguish species in all cases, especially for specimens of R less than 2 mm.

Preserved specimens are often exceedingly difficult to identify and existing keys are, at best, a general guide. There is a great need to investigate new characters, ecological, reproductive and possibly biochemical in an effort to provide reliable characters. It is fortunate that, at least within the "exigua" group, modes of reproduction serve to distinguish specimens of R > 1.5 mm.

In the field only two species are likely to occur in any area and these pairs are readily distinguishable. The combinations are *P. parvivipara* and

P. exigua in South Australia, *P. vivipara* and *P. exigua* in Tasmania and *P. exigua* and *P. pseudoexigua* in southern Queensland. The presence or absence¹ of gonoducts and their orientation, together with colour, are adequate to identify the species.

DISCUSSION

The distribution of the "exigua" crop

The distribution of *P. exigua*, *P. pseudoexigua* and *P. vivipara* was described by Dartnall (1971) and it is interesting to note that *P. parvivipara* is contiguous with *P. exigua*. The distribution pattern is shown in Figure 7.

The geographical separation of *P. vivipara* from *P. parvivipara*, together with the precosity of *parvivipara* strongly supports their separation as distinct species. They are also distinct from *P. exigua* and *P. pseudoexigua* so that along the Australian coastline four similar species exist but reproductive isolating mechanisms have evolved which ensure the integrity of the species concerned. The idea proposed by Dartnall (1971) that the "exigua" group forms a triple sequence may be re-examined. The original idea (Dartnall, 1970) of sibling pairs may be valid and if

¹ Gonoducts are present in *P. vivipara* (F-S, Chia, pers. comm.), but they are difficult to observe, in contrast to *P. exigua* and *P. pseudoexigua*.

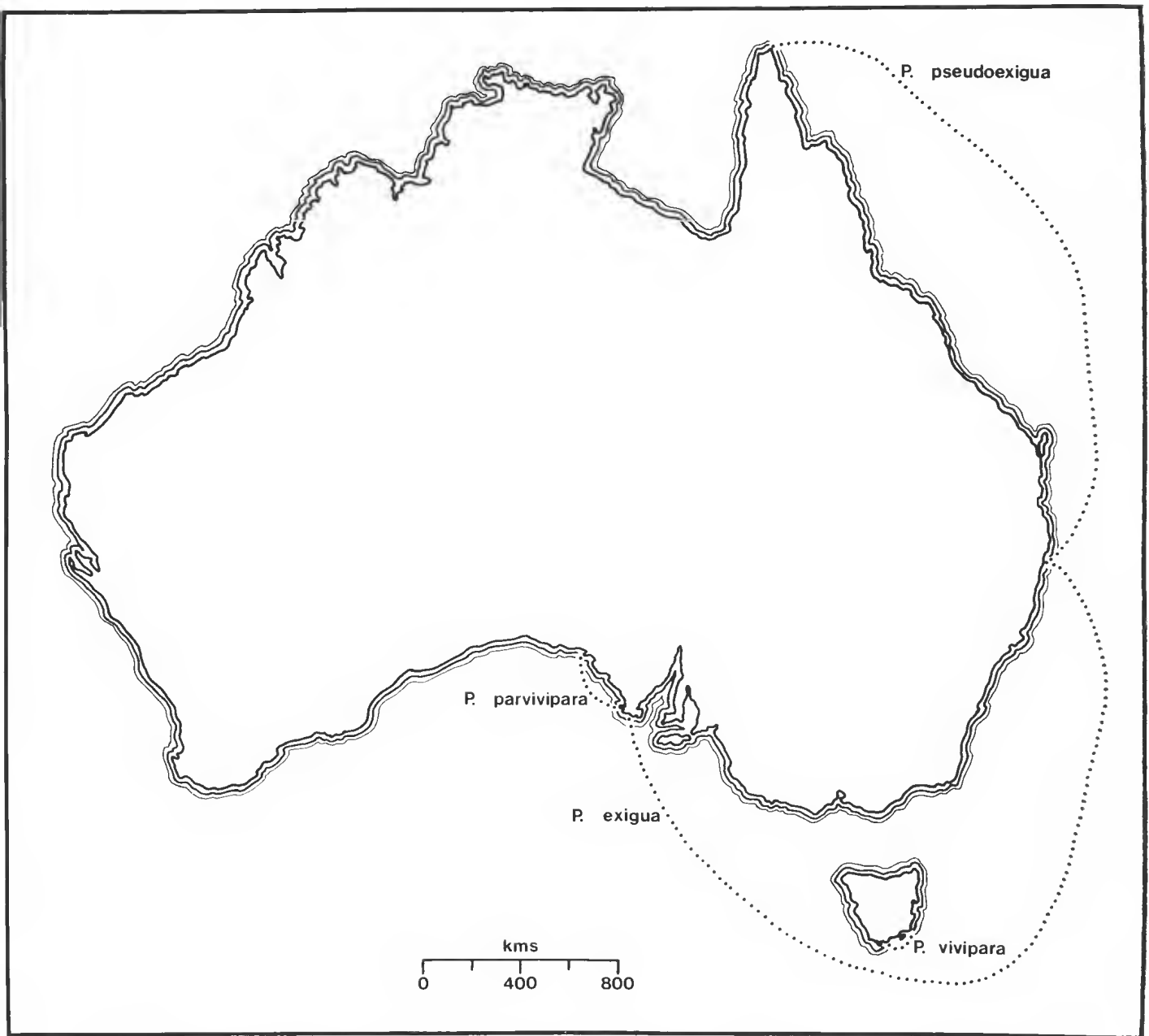


Figure 7. Distribution of *Patiriella* species of the "exigua" group within Australia. Note that the broken lines link only the extremities of the range for each species, and do not indicate presence in water other than the intertidal areas on the Australian coastline

this is so two sibling pairs are now known to exist. There is little intellectual difficulty in deriving both *Patriella vivipara* and *P. parvivipara* from *P. exigua* which lays its eggs in gelatinous packets on littoral rocks and which exhibits an abbreviated larval development. There is also little difficulty if one considers brooding a method of maintaining a consistent recruitment to a restricted, specialised habitat, although it may restrict the dispersal of the species where free swimming larvae are absent.

The reason for the speciation is uncertain, although brood protection is most characteristically a property of cold water species (Mileikovsky, 1971) and it could be argued that cold conditions in the past were involved in the speciation observed. Dartnall (1974), following Gill (1970), has invoked a Pleistocene closing of Bass Strait to explain other marine distributions in the area. Whether this phenomenon, combined with waters of glacial origin in south-eastern Tasmania, and cold subantarctic water washing the shores of the Great Australian Bight, were appropriate triggers for the successful speciation of both *P. vivipara* and *P. parvivipara* must, hopefully, be a source of fruitful argument.

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